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Jagdish Narayan

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EXAMINER

LANGMAN, JONATHAN C

ART UNIT

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**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

<b>Office Action Summary</b>	<b>Application No.</b> 10/593,809	<b>Applicant(s)</b> NARAYAN ET AL.	
	<b>Examiner</b> JONATHAN C. LANGMAN	<b>Art Unit</b> 1794	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☒ Responsive to communication(s) filed on 09 September 2009.
- 2a) ☒ This action is **FINAL**.                      2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 1-11 and 23-26 is/are pending in the application.
- 4a) Of the above claim(s) 5-11, 23, 25 and 26 is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-4 and 24 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All    b) ☐ Some \*    c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
  2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- |   |   |
|---|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)         | 4) <input type="checkbox"/> Interview Summary (PTO-413)           |
| 2) <input type="checkbox"/> Notice of Draftperson's Patent Drawing Review (PTO-948) | Paper No(s)/Mail Date. _____                                      |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08)         | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| Paper No(s)/Mail Date _____   | 6) <input type="checkbox"/> Other: _____                          |

***Claim Rejections - 35 USC § 102***

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for a patent.

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 1-4 are rejected under 35 U.S.C. 102(b) as being anticipated by Zhang et al. (“Formation of Low Resistivity Alpha Ta by Ion Sputtering”).

Regarding claims 1-3, Zhang teaches a tantalum film used in semiconductor industry (pg 237, col. 1, 1<sup>st</sup> pp.). Zhang teaches that the tantalum film is alpha tantalum (pg 237, col. 2, 1<sup>st</sup> pp. of Results and Discussion). As seen in Figure 3, the film has a broad x ray diffraction peak at  $2\theta=38^\circ$ . Furthermore, as seen in Figure 5, the grain size is 12.5 nms and has a resistivity of 32.5 microhm-cm for a tantalum film with a thickness of 10 nms.

Although Zhang is silent to the tantalum film having continuous electron diffraction rings, this characteristic is intrinsic to nanocrystalline alpha tantalum films, as taught by Zhang. Since the prior art teaches the same material as instantly claimed, it is inherent and expected that the prior art film will have continuous electron diffraction rings, as instantly claimed.

It has been held that where the claimed and prior art products are identical or substantially identical in structure or are produced by identical or a substantially identical processes, a prima facie case of either anticipation or obviousness will be

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considered to have been established over functional limitations that stem from the claimed structure. *In re Best*, 195 USPQ 430, 433 (CCPA 1977), *In re Spada*, 15 USPQ2d 1655, 1658 ( Fed. Cir. 1990). The ***prima facie*** case can be rebutted by evidence showing that the prior art products do not necessarily possess the characteristics of the claimed products. *In re Best*, 195 USPQ 430, 433 (CCPA 1977). In regards to claim 4, the prior art is silent to the net diffusion distance properties of the tantalum film. However, since the tantalum film as taught by Zhang is the same structure as instantly claimed, it is expected that the tantalum film of Zhang will behave in the same manner as instantly claimed. See *in re Best* case law applied above.

Claims 1-4 and 24 are rejected under 35 U.S.C. 102(a) as being anticipated by Yuan et al. ("A New Method for Deposition of Cubic Ta Diffusion Barrier for Cu Metallization").

Yuan et al. teach alpha tantalum films deposited on Si substrates to reduce copper metallization from diffusing into the copper substrate (Title, and Introduction section).

Yuan et al. teach that the Tantalum diffusion barrier comprises alpha tantalum, a broad diffraction peak at  $38^{\circ}$ , and a nanocrystalline microstructure (Table 1, Figure 1, and pg 127).

Although Yuan is silent to the tantalum film having continuous electron diffraction rings, this characteristic is intrinsic to the nanocrystalline alpha tantalum films taught by Yuan. Since the prior art teaches the same material as instantly claimed it is inherent

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and expected that the prior art film will have continuous electron diffraction rings as instantly claimed.

It has been held that where the claimed and prior art products are identical or substantially identical in structure or are produced by identical or a substantially identical processes, a *prima facie* case of either anticipation or obviousness will be considered to have been established over functional limitations that stem from the claimed structure. *In re Best*, 195 USPQ 430, 433 (CCPA 1977), *In re Spada*, 15 USPQ2d 1655, 1658 ( Fed. Cir. 1990). The ***prima facie*** case can be rebutted by evidence showing that the prior art products do not necessarily possess the characteristics of the claimed products. *In re Best*, 195 USPQ 430, 433 (CCPA 1977). In regards to claim 4, the prior art is silent to the net diffusion distance properties of the tantalum film. However, since the tantalum film as taught by Yuan is the same structure as instantly claimed, it is expected that the tantalum film of Yuan will behave in the same manner as instantly claimed. See *in re Best* case law applied above.

Claims 1-4 and 24 are rejected under 35 U.S.C. 102(b) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Catania et al. ("Low resistivity body-centered cubic tantalum thin films as diffusion barriers between copper and silicon").

Catania et al. teach a body centered cubic (BCC) tantalum (Ta) film formed on a silicon substrate that has been stripped of its native oxide (table 1, and 3318, col. 2, section c). The term "BCC Ta" is synonymous in the art with the term "alpha phase"

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(see at least [0005] of the instant specification). Catania teach resistivities of 30 micro ohm cm and bcc structured Ta films (3318, col. 2, section d). Alpha Ta films will inherently have a broad x-ray diffraction peak at  $2\theta=38$  degrees and continuous electron diffraction rings. A material and its properties are inseparable. Although Catania et al. are silent to the film having a nanocrystalline microstructure, the applicant has not defined what nanostructured entails. It is inherent that the film comprises a crystalline microstructure, and therefore regardless of the size, the film anticipates the claims, because the applicant has not defined a specific size for "nano".

Where the claimed and prior art products are produced by identical or substantially identical processes, the Patent and Trademark Office can require an applicant to prove that the prior art products do not necessarily or inherently possess the characteristics of the claimed product. Whether the rejection is based on "inherency" under 35 U.S.C. § 102, or "prima facie obviousness" under 35 U.S.C. § 103, jointly or alternatively, the burden of proof is the same, and its fairness is evidenced by the inability of the Patent and Trademark Office to manufacture products or obtain and compare prior art products. *In re Best*, 562 F.2d 1252, 1255 (CCPA 1977).

Regarding claim 4, it is inherent that the article will have a net diffusion distance of less than 10 nm after annealing with copper at a temperature between 650 and 750 for 1 hour (see in re best applied above). Catania teach the same structure as instantly claimed, and therefore it is inherent that the article of Catania will possess the same material properties and characteristics.

Regarding claim 24, Catania teach forming a copper layer on the Ta film (II. Experiments and analysis, A. Apparatus and conditions).

Claims 1-4 and 24 are rejected under 35 U.S.C. 102(b) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Ino et al. ("Ion energy, ion flux, and ion species effects on crystallographic and electrical properties of sputter deposited Ta thin films").

Regarding claims 1 and 2, Ino et al. teach a silicon substrate dipped in HF to remove the native oxide, and a Ta film formed directly thereon. (2629, col. 1 1<sup>st</sup> and 2<sup>nd</sup> full paragraphs). BCC Ta is formed directly on silicon substrates with no intervening layers and has a nanocrystalline microstructure (Figure 9c). BCC Ta is synonymous in the art with alpha Ta). Alpha Ta films will inherently have a broad x-ray diffraction peak at 2theta=38 degrees and continuous electron diffraction rings. A material and its properties are inseparable.

Where the claimed and prior art products are produced by identical or substantially identical processes, the Patent and Trademark Office can require an applicant to prove that the prior art products do not necessarily or inherently possess the characteristics of the claimed product. Whether the rejection is based on "inherency" under 35 U.S.C. § 102, or "prima facie obviousness" under 35 U.S.C. § 103, jointly or alternatively, the burden of proof is the same, and its fairness is evidenced by the inability of the Patent

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and Trademark Office to manufacture products or obtain and compare prior art products. *In re Best*, 562 F.2d 1252, 1255 (CCPA 1977).

Regarding claim 3, Ino do not specifically teach an example with a resistivity of 30-50 micro ohms, however, as seen in Figures 7, 8, and 9a, Ino has established a strong relationship between resistivity and the ion Flux, the film thickness, or the Ion bombardment energy. Ino teaches in these figures a graph that would allow a routineer in the art to extrapolate, any given ion bombardment energy, ion flux or film thickness, in order to obtain a desired resistivity of 0-200 for BCC alpha phase Ta films. Obtaining a desired resistivity, is a known variable in the art, and resistive Ta films are known to greatly effect semiconductor devices and their performance. It would have been obvious to a routineer in the art to adjust these parameters (ion flux, bombardment energy, or film thickness) in order to obtain a desired resistivity, including those resistivity ranges instantly claimed (i.e. 30-50 micro ohms), since it has been held that discovering an optimum value of a result effective variable involves only routine skill in the art. *In re Boesch*, 617 F.2d 272, 205 USPQ 215 (CCPA 1980).

Regarding claim 4, it is inherent that the article will have a net diffusion distance of less than 10 nm after annealing with copper at a temperature between 650 and 750 for 1 hour (see in re best applied above). Ino teach the same structure as instantly claimed, and therefore it is inherent that the article of Ino will possess the same material properties and characteristics.

Regarding claim 24, Ino teaches that Ta films, are known diffusion barriers when inserted between silicon and copper (lines 5 and 6 of the first paragraph). Ino does not



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teach a specific example where copper is deposited on the alpha Ta films on Si substrates; however it would have been obvious to a routineer in the art to do so, as Ino has established that Ta films are known diffusion barrier materials and would offer improved device characteristics.

### ***Claim Rejections - 35 USC § 103***

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claim 24 is rejected under 35 U.S.C. 103(a) as being unpatentable over Zhang et al. ("Formation of Low Resistivity Alpha Ta by Ion Sputtering") as applied to claims 1-4 above, in view of Chen et al. ("Phase Formation behavior and Diffusion Barrier Property of Reactively Sputtered Tantalum Based Thin Films used in Semiconductor Metallization").

Zhang teaches a nanocrystalline alpha tantalum film used in semiconductor industry. Zhang is silent to the specific structure of Si/Ta/Cu, as applied above. However, Zhang in the introduction section teaches that Tantalum films are known in the art and described by Chen et al.

Chen et al. teaches in their introduction section, that tantalum films are used as diffusion barriers when placed between copper and silicon substrates.

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It would have been obvious to a person having ordinary skill in the art at the time the present invention was made to use the tantalum films of Zhang as diffusion barriers for copper and silicon substrates in the semiconductor industry as is known in the art. Combining prior art elements according to known methods to yield predictable results is sufficient enough to establish a *prima facie* case obviousness ((MPEP 2141 [R-6], KSR International Co. v. Teleflex Inc. (KSR), 550 U.S. \_\_\_, 82 USPQ2d 1385 (2007))). Semiconductor devices utilizing tantalum films as diffusion barriers are known structures in the art and would have been an obvious structure to apply to the tantalum films of Zhang.

### ***Response to Arguments***

The applicant amended the claims and respectfully submit that the special technical feature of the claimed articles i.e. tantalum films formed directly upon a substrate surface establishes the requisite Unity of Invention under PCT Rule 13.1 such that pending claims 1-11 and 23-26 are properly examined together without restriction. However, the restriction requirement is still deemed proper between groups I, II, and II, and is therefore maintained. The applicant argues that structures having Ta formed directly on a substrate surface are novel and non-obvious and, thus, constitute a special technical feature. However the arguments presented by applicant regarding this limitation were not persuasive, as discussed below, and, accordingly, the restriction requirement is maintained.

The applicant has failed to apply a proper claim status identifier for claim 23. This claim is improperly identified as “original” and not identified as “withdrawn”. The applicant should apply the proper claim identifier for this claim in the next response.

The applicant amended claims 1-4 to read that “the tantalum film is formed directly on the surface of the substrate”. The applicant argues that Zhang teaches a chromium layer on the silicon substrate, and that Yuan teaches a TaN interlayer between the tantalum film and the silicon substrate. The applicant argues that these teachings of interlayers fail to read on the claims as presented.

The Examiner disagrees.

The applicant’s amendment to the claims is to place the Ta film directly on the substrate. The applicants argue that there should be no layers present between the “substrate” and the Ta Film . However, in regards to claims 1-4, the applicant never defines what the “substrate” is made of. Multilayer substrates are well within the scope of the claims as presented. Therefore the multilayer substrates of Yuan (Silicon/TaN) and Zhang (Si/Cr) still anticipate the claims as presented.

In regards to claim 24, where the applicant actually defines the substrate as being a silicon substrate, the applicant merely claims that the nanocrystalline Ta film is “deposited on” the Si substrate. The applicant does not use the phrase “directly on” and therefore structures that may comprise intervening layers, such as those taught by Zhang and Yuan, still anticipate the claim. To further support the Examiners position of their interpretation of “formed on”, the Examiner points the applicant to withdrawn claim 26, which teaches that interlayers may be formed between silicon substrates and Ta

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layers, even though, the Ta layers are “deposited on” silicon substrates as presented in withdrawn claim 25.

It appears that the applicant was making a whole hearted attempt to further limit their claims. In an effort to advance prosecution, the Examiner has provided new references Ino and Catania which both teach the formation of bcc (alpha) tantalum films directly on silicon substrates as diffusion barriers to copper. Both of these references teach the stripping of the native oxide from the silicon so that the Ta films will be directly on the Si substrates.

### ***Conclusion***

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

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Any inquiry concerning this communication or earlier communications from the examiner should be directed to JONATHAN C. LANGMAN whose telephone number is (571)272-4811. The examiner can normally be reached on Mon-Thurs 8:00 am - 6:30 pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jennifer McNeil can be reached on 571-272-1540. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

JCL

/Timothy M. Speer/  
Primary Examiner, Art Unit 1794